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IEEE-USA WHITE PAPER

TECHNOLOGY EVOLUTION AND ELECTRIC MARKET REFORM

PREPARED BY THE
IEEE-USA ENERGY POLICY COMMITTEE

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About IEEE-USA

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Technology Evolution and Electric Market Reform Supporting Background and Discussion

Summary:

Changes in technology are forcing an evolution of the U.S. electric system. It is quickly shifting from one consisting of centralized power plants and static consumers towards a dynamic combination of distributed producers and consumers, who have increasing options to control their own production and consumption. This shift has introduced bi-directional flow of power on distribution systems, creating both technical challenges in system operation, as well as economic challenges in establishing the value and optimum mix of the many new technologies now available. The wholesale and retail electric market structure and regulatory oversight of these markets must also evolve to reflect these changes, and to better support development of a 21st century electric power grid. As technology develops at an exponential pace, regulation must progress in parallel.

The IEEE-USA Position Statement on Technology Evolution and Market Reform outlines principles to guide continued development of market structures that support advanced electrical technologies.

https://ieeeusa.org/wp-content/uploads/2018/11/ElectricMarketReform1118.pdf

This paper is intended to provide additional background and perspective on the linkage between implementation of advanced technologies and market forces and the need to consider both in combination.

Historically, vertically integrated utilities, overseen by state regulators in most of the United States, planned for the grid's electrical supply and operation.[1]

The electric supply planning and operations was once reasonably straightforward and readily understood. The responsible utilities' management and staff typically conducted planning and operations based upon internal costs and technical data they developed and implemented. Further, utilities performed integrated resource planning (IRP), used since the 1980s, based on utility-generated load forecast predictions. IRP represented the first attempt to reflect customer-side programs, such as energy efficiency programs in system planning. However, for all practical purposes, the utilities could treat the changes in load levels (due to energy efficiency, demand response and some customer generation) exogenously.

Throughout the United States operation of the high voltage grid was controlled by either utility staff or, in some regions, through authority delegated by the utilities to power pools. Lower voltage

1 The Federal Power Marketing Administration (TVA,BPA)can also provide generation and transmission services, state created non-profit firms, or generation & transmission (G&T) co-ops. "The History and Evolution of the U.S. Electricity Industry", University of Texas at Austin Energy Institute, July 2016, Pg. 13

distribution systems were planned and operated by the local utility, municipality, or electric cooperative. Regulators reviewed and approved investment plans and rates.

While electric industry structure has evolved over the years, the fundamental technical objectives remain the same. Today, as in the past, high-voltage grid system operators rely on a mix of energy sources to provide reliable and efficient electrical service as demand changes every minute of every day.

The United States derives its electric generation mix today primarily from coal, nuclear, gas, hydroelectric, or increasingly renewable energy. We use very little oil to power generators. We have used hydroelectric pumped storage, in some instances to store energy, but now battery energy storage is a growing part of the mix. Each source of electric power has pros and cons, but the mix must always meet instantaneous demand and minimize interruptions that unusual weather patterns, or extensive forced outages of generators, can cause. The ability to achieve this objective depends upon having the necessary infrastructure in place; the necessary data and operational tools available to operators; and financial and market incentives in place, to optimize economics and reliability, as the system changes.

Over the last 20 years, the industry has evolved, and it continues to change as increased deregulation and industry restructuring have introduced greater competitive forces, and added complexity in planning and operating processes.

Restructuring and Deregulation Defined:

Electric industry restructuring may be defined as the evolution from vertically integrated utilities responsible for all aspects of electric supply in their geographical footprint, toward a disaggregated market structure in which different entities may be responsible for different functions within the overall market and supply chain. Today there is typically vigorous competition between generation and demand-side resources across large regions spanning the historical footprints of multiple integrated utilities.

In contrast, we can define *deregulation* as a shift from a business model where electricity prices are administratively set pursuant to a regulatory process to one in which prices buyers pay are set by forces of supply and demand in defined markets and/or by contracts negotiated between counterparties. This process constitutes a shift from regulating the utilities, to regulating the markets in which the utilities operate. Some functions within the electric business, such as generation supply, lend themselves to competition better than others such as transmission and distribution services, which exhibit characteristics of natural monopolies.

Restructuring and deregulation are complementary but different processes. Deregulation is a process driven by regulatory or legislative action; while restructuring may also be driven by changes in business strategies, new market opportunities or new technologies. Restructuring has affected all aspects of the electric business in some way over the past two decades, but it has not occurred in a uniform manner in all regions of the United States. Deregulation has similarly proceeded in a non-uniform manner, with states and regions defining their electricity markets in different ways, reflecting regional differences in generation and use.

We can trace the genesis of today's industry restructuring to 1978, when a series of legislative and regulatory rulings caused the industry to enter a period of change. Key governing policy documents include PURPA (*Public Utility Regulatory Policy Act*), FERC (Federal Energy Regulatory Commission) Order 888, the *Energy Policy Act of 2005*, including mandatory NERC reliability standards and FERC Standards of Conduct. FERC's establishment of open-access transmission service and the related changes in the flow and use of information held by transmission owning utilities are of particular importance. Open access transmission opened the door for competition in the generation sector of the business. Utilities were barred from exercising vertical market power and were required to allow interconnection of generators owned by independent generators to the transmission system. Owners of transmission assets must now

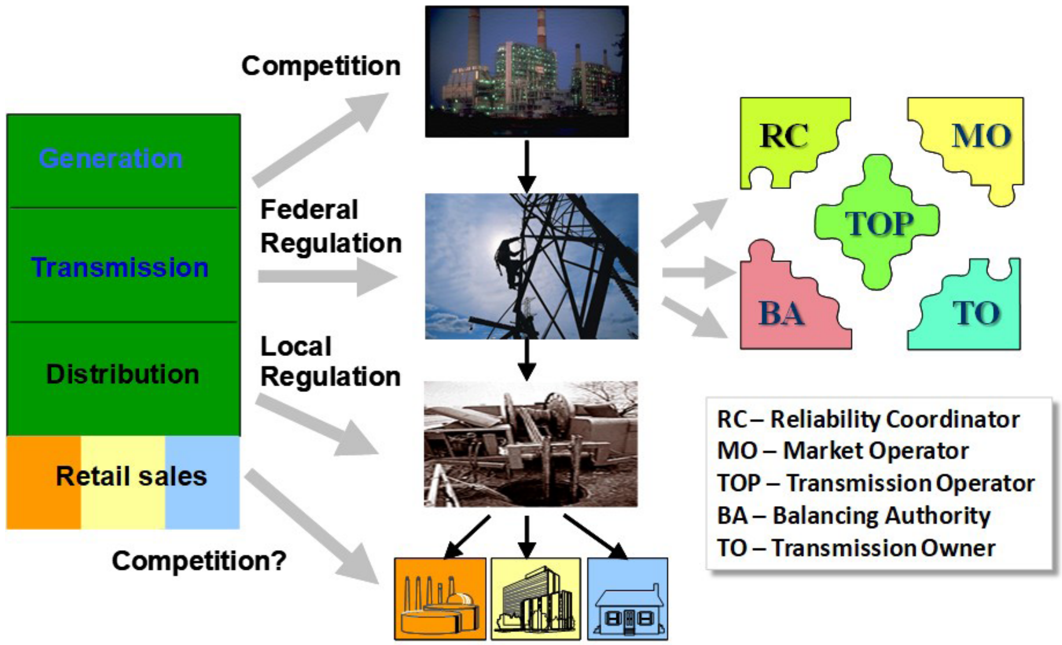
provide transmission service to all competitors on the same terms that they provide it for themselves or their affiliates. In addition, under FERC Standards of Conduct, information regarding planning and operation of the transmission system may not be shared privately with other departments of a company also engaged in generation or energy marketing. This standard is intended to prevent the transmission-owning utility from gaining unfair competitive advantage from this knowledge. Such information must be made publicly available, on an equal basis, to all competitors in the energy markets. This was a significant change compared to prior utility practices.

In addition, some states decided to eliminate monopoly supply of electric generation to retail customers and to open these markets to give customers a choice of providers. These decisions often led to the sale of all generating plants by the incumbent utility to resolve market power concerns. Other states have retained a vertically integrated utility model, but subject to provision of open-access transmission service.

These regulatory and legislative decisions ultimately led to a large-scale restructuring of the utility business in half of the country. Operations and planning became more closely linked to market forces, and many new participants and businesses became engaged in markets once restricted to participation by relatively few utilities. The number of players involved in the markets increased significantly. Organizational structures of regulated utilities were optimized to succeed within the new regulatory requirements. The degree to which these changes were implemented varies regionally across the United States, driven largely by choices made by policymakers at both the federal and state levels.

Figure 1 depicts the various functions and relationships now prevalent in electric markets today. Figure 1 generally parallels the functions outlined in greater detail in the Reliability Functional Model of the North American Reliability Corporation (NERC) (https://www.nerc.com/pa/Stand/Pages/FunctionalModel.aspx), and in the various operating and tariff agreements now utilized throughout the country. The NERC functions define responsibilities for compliance with mandatory reliability standards for the high-voltage grid, but can also define divisions and contractual relationships and responsibilities of business entities and market participants. The structure is much more complex than is generally recognized by many of those not directly involved in the industry.

FIGURE 1.



Of key importance is the recognition of four core electric supply functions within the diagram. These are: Generation, Transmission, Distribution and Retail Sales (NERC Load-Serving Entities). In some U.S. markets, four separate business entities may perform these functions. In others, mainly areas with traditional vertically integrated utilities, they are not. Like markets for other goods and services, there is also a boundary between wholesale and retail markets, but the rules, structure and oversight of these markets varies regionally across the United States.

In summary, while restructuring and deregulation unleashed competitive forces and enabled new business entities, new customer choices, and new financial incentives, it did so by introducing additional boundaries into planning, operating and financial processes. In turn, adding additional boundaries has resulted in additional technical and regulatory complexity.

Wholesale Electric Markets:

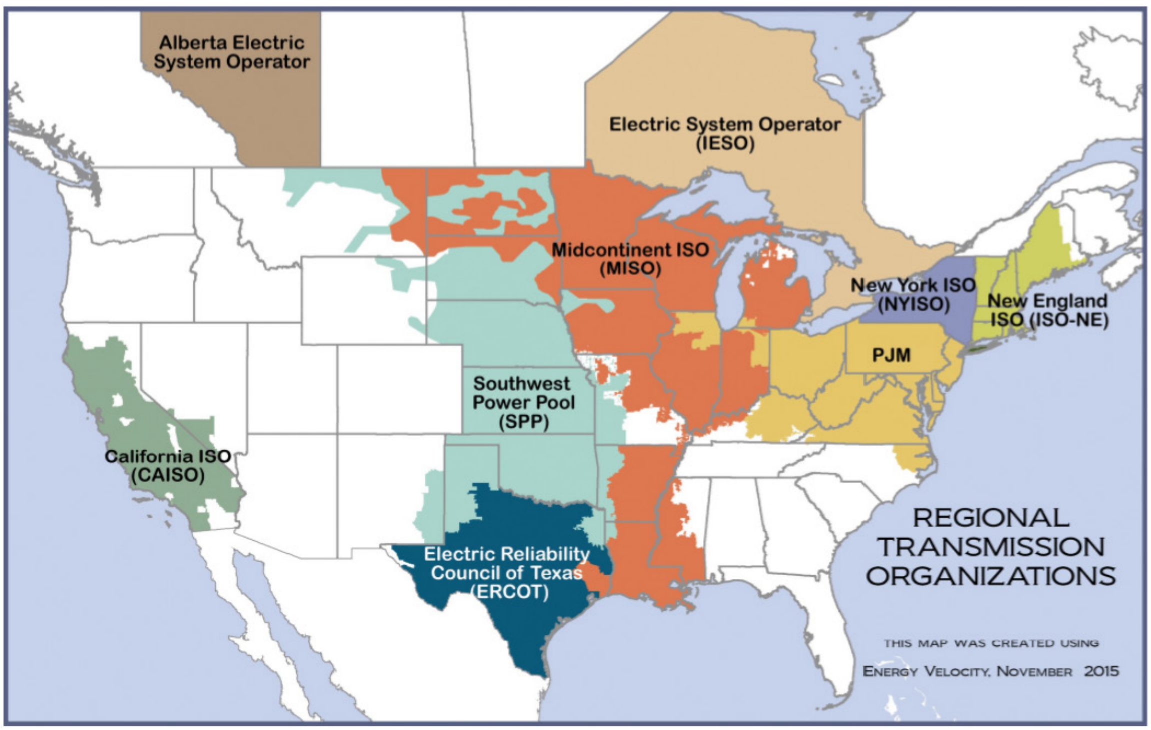
Wholesale electric markets generally encompass a larger area, while retail markets are defined by utility service territories at the state level. It is particularly important to consider the relationship between the separate wholesale and retail electric markets, as this relationship will affect how new technologies are valued and deployed. These markets are distinct from each other, but linked by the relationship between supply, demand, and price.

Longer term transactions in the wholesale market occur primarily between generators and retail Load Serving Entities (LSEs), who are responsible for service to end-use customers, and the ISO/RTO facilitates the day-ahead and real-time energy markets. Various unbundled products are bought and sold in these markets, including capacity, energy, and various ancillary reliability related services.

According to the U.S. Supreme Court, transmission of electricity across state boundaries in the wholesale markets is interstate commerce.[2] Thus, the Federal Energy Regulatory Commission (FERC) — and not the state public utility commissions — provides transmission service and the electric market rules used by multi-state ISOs/RTOs (Independent System Operators and Regional Transmission Organizations.) Further, FERC, and not state public utility commissions, regulates the mandatory reliability standards for the high-voltage grid (Bulk Electric System) in most of the country.

About 2/3 of the United States, now relies on open regional wholesale markets with offer-based, transparent, real-time pricing. The ISOs and RTOs run these markets. The map in Figure 2 shows ISO/RTO boundaries. In many cases, the ISO/RTO footprint consolidated the areas of multiple, previous-transmission owning utilities, with the intent of facilitating competition by establishing independent oversight of transmission service, grid operations and wholesale markets for generation.

FIGURE 2



Source: Federal Energy Regulatory Commission https://www.ferc.gov/industries/electric/indus-act/rto/elec-ovr-rto-map.pdf

Within ISO/RTO regions, wholesale market participants may choose to engage in one or more independent functions (FIGURE 1) but not in others depending upon their assets, business objectives

2 US. Supreme Court Orders in New York Public Service Commission v. FERC (Nos. 00-568, 00809) and 16 U.S.C. § 824(b)(1). There are other limitations on FERC jurisdiction under the FPA. Publicly-owned and many cooperatively owned utilities are subject to only limited elements of the FPA. 16 U.S.C. §§ 824(f), 824(b)(2). Moreover, the entities found not to be operating in interstate commerce, i.e., entities in Alaska, Hawaii, and the ERCOT portion of Texas, are also subject to only limited FPA Part II jurisdiction. Footnote 23, pg. 3, "Implications for Emerging Electricity Technologies", by J.S. Dennis, S.G. Kelly, R. R. Nordhaus, D. W. Smith, for Akin Gump Strauss Hauer & Feld LLP, Van Ness Feldman, LLP, produced by Energy Analysis and Environmental Impacts Division Lawrence Berkeley National Laboratory December 2016.

and strategies. Freedom of market entry and exit for businesses, and the ability to supply various energy and technology products to the ISO/RTO (or other market participants) exists, subject to FERC-approved market rules, reliability standards, and other ISO/RTO requirements.

In regions with ISOs/RTOS, each ISO/RTO proposes market rules in coordination with its stakeholders.[3] It is critically important that market participants, state regulators, and other stakeholders have a voice in how the regional market rules evolve as this evolution will have a great impact on suppliers and customers across the entire spectrum of the market. Grid reliability, costs to customers, and business profitability all depend upon establishing fair and stable wholesale market rules in ISO/RTO regions.

Wholesale market designs are subject to FERC approval, except for the cases of ERCOT in Texas, Hawaii and Alaska: states not strongly interconnected to the rest of the grid. Despite FERC efforts in the early 2000s, is the United States has no standard wholesale market design. Thus, the regulatory process has resulted in some variations in wholesale market rules between ISOs/RTOs — reflecting regional needs and preferences on market design. However, all ISOs/RTOs reflect the business relationships shown in Figure 1, and all of the restructured wholesale markets, including those in ERCOT, have broadly similar, offer-based locational markets — in both the context of day-ahead (providing for commitment of units and a short-term forward market) and real-time operations (functioning as the spot market for electrical energy).

Regions serving between one quarter and one third of the United States have not established ISOs/RTOs and maintain more traditional bilateral markets consisting primarily of regulated utilities, public power, and rural cooperatives. These regions do not provide offer-based locational markets, as implemented by ISOs/RTOs, and operate in a notably different fashion. Nevertheless, changes such as open access transmission and development of advanced, behind-the-meter technologies that can affect customer demand, have affected such regions. As previously described, FERC Standards of Conduct for information sharing creates arm's length relationships across some segments of the businesses, even though they may reside under a single corporate entity.

In these non-ISO/RTO regions, utilities oversee operation of the grid and manage transmission service provision. Such oversight and management typically involve fewer market participants. Stakeholder input is still important, but the means by which stakeholders provide such input is different from ISO/RTO regions where there are stakeholder committees and meetings. Utilities drive more deployment of new technologies in non-ISO/RTO regions where greater opportunity exists for third party engagement.

Retail Electric Service:

Market rules set by the states in retail markets are different than FERC-set market rules in wholesale markets, reflecting differences in the nature of customers served, operational factors, and regulatory objectives. In contrast to regional wholesale markets, retail markets focus on terms of service and prices to large and small end use retail customers. Retail electric service, distribution

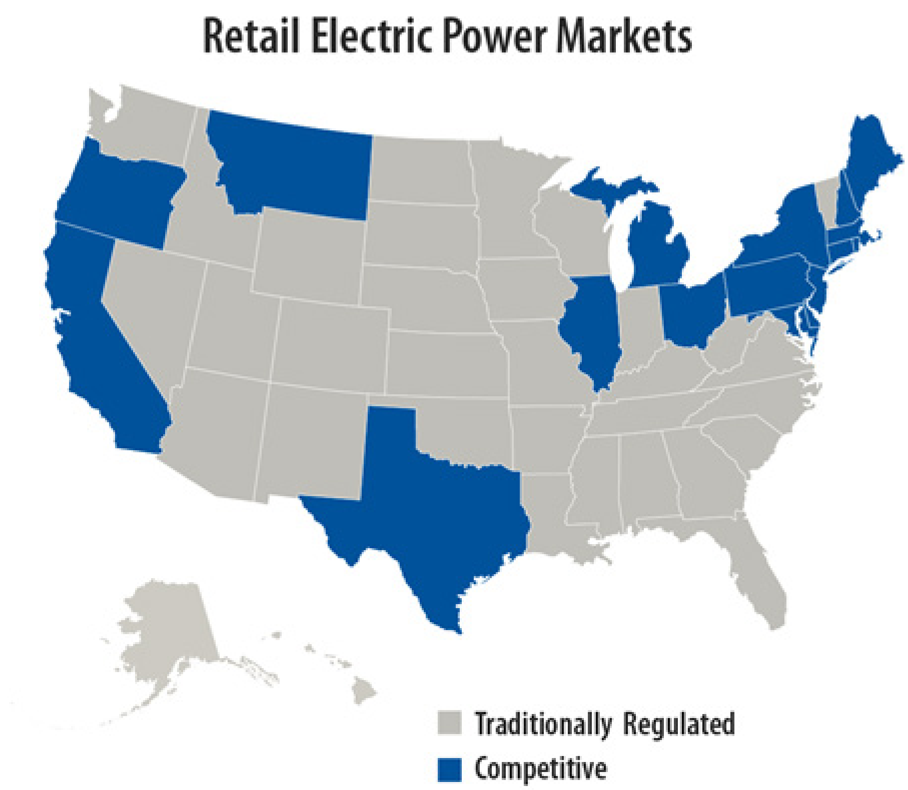
3 Stakeholders are anyone with a stake in the operation or financial outcome related to electric grid operation. Simply stated, they are physical and financial parties affected by the rules — such as producers, users, buyers, sellers and regulators.

delivery service, rates and access to alternative electric suppliers (LSEs), are under state jurisdictions and reflect the local nature of the distribution system operation, as well as each state's specific public policy objectives.

Prior to electric utility industry restructuring, the retail rate structures were generally more limited. Rate options become more varied with rising concerns about generation shortages and emerging customer technology options to aid in solving these issues — e.g., demand response (load management with or without remote control), rates, and even experimental real-time pricing. These technologies were largely well received, but generally did not advance beyond test. Some utilities offered time-differentiated rates, which were necessary to support thermal storage systems. Customers rarely adopted these rates otherwise.

As wholesale supply turned into a mostly competitive market in some parts of the country, the expectation was that similar changes would be implemented on the retail side. Figure 3 shows states in which retail customers may choose an electric energy supplier other than the local utility. Although competitive retail supply has been tried widely throughout the United States, after decades, few retail electric markets are truly competitive.

FIGURE 3



Source: https://www.epa.gov/greenpower/us-electricity-grid-markets

Price Signals and Financial Incentives:

The variations in wholesale and retail market designs leads to local and regional differences in electric price signals provided by the markets. In any market for any product, wholesale or retail, both buyers' and sellers' behavior will reflect the prices and - economic incentives. Supply, demand, and price are related. Electric markets are no different. Technologies that change either supply or demand patterns also affect electricity prices. How customers perceive price can affect their consumption decisions at both the retail and wholesale market levels. In turn, consumption levels and patterns affect electric systems planning, design, and operation at all market levels. In some circumstances, incorrect price signals to consumers, or lack of price transparency, may cause inefficiencies or unintended outcomes, in some circumstances.

The local optimization in market designs creates varying degrees of effectiveness in economic signals across the markets. Technologies that may be optimal in some regions, may be deployed differently or not at all in others because the business case will depend in part on the local market and pricing design. For example, in some markets energy storage may derive some revenue from capacity payments, but this may not be a consideration elsewhere. In any case, policymakers may wish to fully evaluate the potential impact of both pricing structure and transparency at wholesale and retail levels when pursuing deployment of various technologies.

In parallel with industry restructuring and its complexities, rapid technological advancements encompassing all aspects of supply, delivery and utilization are also affecting the optimal generation and use of electricity that were not possible when the markets were defined. Change, driven by both restructuring and new technology, presents opportunities and risks for grid reliability, customer service and cost.

Reliability Risks, Opportunities and New Technologies:

New technologies can lower cost and increase choices for consumers, but their implementation must also address risks to reliability. Risks include added complexity in long-range planning, managing variable output of renewable resources, and inadequate transmission capability to support new technology deployment.

NERC reliability standards that apply to all markets provide requirements for managing risks to the Bulk Electric System. These enforceable reliability standards, established pursuant to the ***Energy Policy Act of 2005*** (**EPAct 2005**), are the foundation for maintaining a reliable high-voltage grid. All standards must be respected when deploying new electric supply and demand-side technologies. Market and rate designs, in both ISO/RTO and non-ISO/RTO regions, that align with reliability standards can help mitigate the risks and enable the ability to seize the opportunities new technologies present.

Technology advances are also making distributed generation an economical option in a growing number of situations. This option may be particularly viable where the policies needed to support a reliable grid add sufficient cost, so that other solutions are competitive. Consequently, both emerging technology and the cost of necessary regulation may combine to provide an incentive to build generation, rather than transmission. As it does, the cost of the grid regulation increases for the remaining grid consumers.

At the retail level, new technology is increasingly providing options to customers that allow them to assume greater responsibility for their own supply reliability. Available technologies now include backup generators, home solar power, and batteries. In aggregate, this technology's increasingly rapid growth and widespread deployment can affect both grid operations and prices at a regional level and compliance with the mandatory NERC standards. Thus, a critical need exists to ensure that local retail market rules support regional reliability objectives, helping to avoid operating problems on the high-voltage grid. Further, these technologies can also create overload risks, and voltage problems on local distribution systems.

While we must manage such risks, the new technologies also provide great opportunities for improved reliability by expanding the number and type of resources available to system operators. For example, it may be possible to aggregate resources installed at retail customer sites into "virtual power plants" that can be integrated into wholesale market operations to provide reserves and frequency control services. Vehicle to Grid (V2G) technologies have also been proposed and researched to explore optimized use of energy storage systems in electric vehicles. It may further be possible to use these and other localized distributed resources to provide backup power and respond to outages on transmission or distribution systems. Potential technology benefits are not limited to, and may ultimately not include, these examples — but they illustrate the type of opportunities we can best implement, with market design and regulatory policy coordination between the wholesale and retail levels.

Restructuring Risk, Opportunities, and New Technologies:

The new technologies' relative economic effectiveness and optimal operational deployment largely depends on the restructured markets' wholesale and retail pricing designs and regulatory rules into which they will be deployed. Current market designs were chosen without any knowledge of the capabilities of the emerging technologies. New technologies, such as demand management, distributed renewable generation, electric vehicle recharging, and energy storage can change customer demand, generation supply, transmission/distribution flows, and price patterns. The pace of new technologies' deployment will reflect the financial incentives rules, or disincentives local and regional markets impose.

One emerging issue is that retail market rules and rates, as historically defined, can create price signals that encourage customers to increase or maintain usage, and/or curtail demand-, at times when the bulk electric system is constrained — to preserve reliability. The widespread use of volumetric pricing (cents/kwh) typical for decades at the retail level can potentially affect high-voltage grid operation. This form of pricing is simple for consumers to understand, but it can diverge widely from the real-time wholesale prices that create the economic signals used for reliable dispatch of generation, operation of demand response, and f transmission overload relief.

The timing of charging electric vehicles is an example of this potential concern. Constant volumetric retail prices provide no economic signal to customers to defer charging from times when wholesale power supplies may be critically limited. Home solar and storage deployment may also be suboptimal if local retail rates and regulations, particularly net metering programs, are not aligned well with prices and reliability requirements of the bulk power system.

Volumetric pricing has not been a major issue yet because new customer technologies have not been widely deployed in most regions; and utilities have developed methods to statistically predict and manage them. This situation could become a more important concern if there is widespread market penetration of electric vehicles, energy storage, and/or other new technologies by retail customers.

While market rules have a large impact on the deployment of new technologies, the technologies can likewise have a profound impact on the structure of the market rules in ISO/RTO regions. Effects were evident first in the wholesale energy markets, and later, in the capacity markets. Many of the new technologies affect ancillary services, like reserves and energy balancing (frequency control). In ISO/RTO regions, it is not uncommon to add a new market product when market participants need compensation for supplementary services they may provide (e.g., fast-start capability, energy storage, demand response, and other auxiliary functions). Non-RTO regions approach this issue differently since they do not operate open wholesale markets for the various products.

Jurisdictional Boundaries and New Technologies:

Figures 2 and 3 illustrate the overlaying RTO, federal and state regulatory boundaries and the resulting market and regulatory environment complexity in the United States. Such complexity is likely to lead to regional and state differences in economic viability, selecting new technologies, and differences in the costs and benefits customers may experience.

Some technologies can be valued and monetized in both bulk and distribution systems. Hence, new approaches are needed to manage the increasing number of technologies that cross system and jurisdictional boundaries. These approaches must overcome the friction that has developed between state and federal regulators. This friction is also reflected in critical transmission investments stagnation, particularly for projects whose benefits flow to customers beyond state borders. It may well become an obstacle to the implementation of the congressionally mandated Smart Grid.

Jurisdictional disputes need effective management to assure grid reliability, customer service, consumer cost reduction, and achievement of other public policy objectives — especially if the United States is to take the best advantage of 21st Century technological opportunities.

The rapidly evolving technological landscape requires a corresponding evolution of regulatory policies and market rules governed by a set of core principles. This evolution is applicable to both ISO/RTO and non-ISO/RTO regions. A key challenge is that legally established market structures are based on legacy and not emerging technologies

To manage risk and capture opportunities, regulatory policies and market designs must keep pace with both relevant market dynamics and the advance of technology. Going forward, it will be important to avoid unintended consequences in both local and regional markets.

Public policies under consideration, such as renewable portfolio standards, tax incentives and carbon pricing may have considerable impact on choice of technology. In addition, state regulatory requirements for transmission siting can block Bulk Electric System expansion to meet regional and national energy objectives. The extent of these concerns varies regionally, and regions served by vertically integrated utilities under state regulation manage them differently, compared to regions with active competitive generation markets.

We must not only consider regulations affecting electric market prices. In some cases, we must also realize that regulations directed toward achieving other public policy objectives may affect market prices in ways that result in inefficient or unexpected outcomes as we deploy new resources. In other cases, some may choose subsidies, as a tool to achieve optimal technology choices in defective markets.

Given the detail and complexity of the challenges, it will be important to maintain focus on the goals — such as those outlined in the ***IEEE-USA National Energy Policy Recommendations***[4] — and to rely upon the above recommended core principles, to help guide debate and decision-making.

Conclusion: Seize the Opportunities

The United States is at the threshold of a technical revolution that will significantly alter the electric grid, and the operation of its markets. Old technologies will diminish, and new ones will be brought to market. Many technologies, such as solar and wind power in some regions, are already here and succeeding. Policymakers should be open to this future, look for opportunities, and not be wedded to past practices. At the same time, the changes on the horizon are not without some risks to reliability and customer service. Changes and risks are of growing importance as electricity is key to more and more of our economy and lifestyle. The United States needs a disciplined approach, to assure a successful transition to a secure and vibrant electric energy future.

Attempting to implement identical wholesale and retail market rules across all states is unlikely to succeed due to differences in regional and state operating conditions, economic priorities, and policy preferences. Nevertheless, continued and complementary evolution of both wholesale and retail regulatory, market and pricing rules — both within ISOs/RTOs and outside of them — is essential for the United States to seize the opportunities available, economically optimize deployment of both existing and new technologies, preserve grid reliability, and advance federal and state clean power objectives. Market and reliability rules must provide available and accurate information on a timely basis, to those responsible for long-term planning, development and operation of the grid.

4 https://ieeeusa.org/wp-content/uploads/2019/11/NEPR1119.pdf

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